7.0 IDENTIFICATION AND SELECTION OF TECHNOLOGIES AND PROCESS OPTIONS

In this chapter, technologies and process options are identified for evaluation which fully cover the range of known available options capable of achieving remediation of the contaminated sediments.

7.1 IDENTIFICATION OF TECHNOLOGIES AND PROCESS OPTIONS

The full range of technology types and process options that potentially can be used for remediation are identified. Technologies and process options have been compiled based on previous project experience, literature searches, and correspondence with appropriate agencies. The term "technology types" refers to general categories of technology, which for this project include:

- No Action
- Natural Recovery
- Excavation
- Treatment
- In-Water Containment
- Upland Disposal

The term "process options" refers to specific processes within each technology type. For this project, the following process options are identified:

- No Action
- Natural Recovery
- Excavation
  - Mechanical Dredging
  - Hydraulic Dredging
- Treatment
  - Bioremediation
  - Soil Washing
  - Thermal Treatment
    - Holnam Cement Plant
    - Portable Thermal Plants
    - Lightweight Aggregate from Dredged Sediments (LADS)
    - Incineration
- In-Water Containment
  - In situ Capping

- Thick Layer
- Thin Layer
- Inverted

* Confined Aquatic Disposal
* Nearshore Confined Disposal

- Upland Disposal
  * Landfills
    - Resource Conservation and Recovery Act (RCRA) Subtitle D Landfill
    - Hazardous Waste Landfill
    - Municipal Landfill Closure
  * Miscellaneous Disposal Locations
  * Construction Backfill

Technology types not identified for evaluation include in situ treatment technologies to achieve solidification, stabilization, and/or treatment. Although conceptually possible, in situ treatment technologies have not yet been adequately demonstrated or implemented. They would require significant basic research and pilot studies to demonstrate their effectiveness. Even with the additional research, there would be no guarantee that the systems could be cost effectively implemented or permitted. The costs associated with testing and demonstration would cause these actions to be significantly more expensive than other available effective options for this site.

7.2 SELECTION OF TECHNOLOGIES AND PROCESS OPTIONS

To eliminate those technologies and process options that clearly are not reasonable for the Norfolk Cleanup Study, an initial screening is performed. Only those options with good potential are retained for detailed evaluation. The key criteria for the screening are:

- **Technical effectiveness.** Will the technologies and process options effectively clean up the site?
- **Implementability.** Is the technology or option clearly not permittable or does it appear to have significant difficulty in permitting? Will the option or technology result in confinement of untreated sediment on DNR land? Both DNR and Ecology prefer that contaminated sediment is removed from the site (i.e., permanent solution). Does the site have significant logistical problems for construction?
- **Cost effective.** What is the relative cost of each technology option? Technologies and options with high relative costs are eliminated.
- **Adverse impacts.** Technologies and options that may cause significant (i.e., not easily mitigated) adverse impacts are eliminated.

7.2.1 No Action

Under this option, no remedial action would be conducted and no institutional controls or long-term monitoring would be performed. The No Action option is not an effective technology for cleaning up the site. All contaminated sediments would remain on the site, which is contradictory with Ecology and DNR preferences for removal. This option is low cost, since no actions would be performed at the site. The PCB hot spots identified in the site assessment would remain. This option is carried forward to provide a baseline for comparison.

7.2.2 Natural Recovery

This option is believed to have limited technical merit for the Norfolk sediments, since sedimentation rates are low and contaminants such as PCBs and mercury are persistent in the environment. The timeframe for natural recovery cannot be predicted with the available information. This option requires no permits or construction. No adverse impacts (beyond current levels) would be encountered with this option and any cost associated with natural recovery would be minimal and used for monitoring. However, this option will likely not be implemented for this project for several reasons. The EBDRP Panel desires to remove contaminated material from the site. Also, both DNR and Ecology prefer that contaminated sediments be removed from the site. Based on the above reasons, this option has been eliminated from further evaluation.

7.2.3 Excavation Options

Applying the screening criteria to excavation options yields the following results:

Dredging (mechanical). Sampling results indicate that the maximum depth of contamination is approximately two feet deep, thereby making it technically effective to mechanically dredge and completely remove all contaminated sediment from the site. This option is proven and accepted technology, so permitting is relatively straightforward. Removal of contaminated sediment complies with Ecology and DNR preference for removal. The option is cost effective and no adverse impacts are foreseen that cannot be mitigated. This option is carried forward for further analysis.

Dredging (hydraulic). Sampling results indicate that the maximum depth of contamination is approximately two feet deep, thereby making it technically effective to hydraulically dredge and completely remove all contaminated sediment from the site. This option is proven and accepted technology, so permitting is relatively straightforward. Removal of contaminated sediment complies with Ecology and DNR preference for removal.

Due to the large amount of water entrained during the hydraulic dredging process (typically 80% to 90% water), logistics are significantly more complex than for mechanical dredging. The design must account for handling and treatment of the water which is entrained prior to return to the receiving water. Due to the lack of adequate suitably sized upland staging area(s) to allow for cost-effective dewatering, the logistical and/or cost constraints eliminate this option in favor of mechanical dredging. The exception is where hydraulic dredging can discharge to barges with no overflow, followed by treatment and drainage of free water from the barge. In this case, the option is implementable and cost effective. To allow for this specific condition, this option is being carried forward.

7.2.4 Treatment Options

Applying the screening criteria to treatment options yields the following results:

Bioremediation. Bioremediation is effective on many organic contaminants, but generally not effective on heavy metals contaminants such as mercury or on persistent organics such as PCBs. Extensive additional evaluation would be required to determine whether a bioremediation method may be effective for use at this site. Removal of the sediment offsite would initially be required in order to implement this option (i.e., dredging then bioremediation). Typically, bioremediation involves extensive material handling and material working. The logistical constraints are significant and would require extensive evaluation to define. Costs to test and prove the technology are high. Based on the above reasons, this option has been eliminated from further evaluation.

Soil Washing. This option has potential for project sites with large volumes of sediment containing significant percentages of sand (this project contains sandy sediment but the volumes are relatively small). To our knowledge, this option has not been applied to dredging projects. Pilot scale studies would be required to determine the applicability of this technology, especially to find a washing agent that would be effective on both organic COCs and mercury. This would be considered an experimental project and difficult to permit. Significant testing and research would be required to demonstrate the technology effectiveness. Removal of the sediment from the site would initially be required in order to implement this option (i.e., dredging then soil washing). High unit costs due to small volumes make this option cost ineffective. Based on the above, this option has been eliminated from further evaluation.

Thermal Treatment (Holnam Cement Plant). Holnam may be able to use the dredged material as raw material to create cement with its rotary kiln process, thereby recycling it. The process to produce cement raises the raw feed stock (i.e., sediment, soil, sand and contaminants) to very high temperatures (i.e., up to 2600 degrees Fahrenheit). This causes the material to become semi-molten, forming the cement. During this process, organics are destroyed and heavy metals are immobilized in the clinker at the bottom of the kiln, making them unavailable to leaching, and then ground and combined with gypsum to make cement (Schneider, 1994).

This technology is proven and effective and has been permitted for previous projects. Costs for treatment at the facility are roughly equivalent to disposal at a landfill. A special feature of the plant is that it is a wet processing facility and therefore can take either wet or dewatered material. Removal of the sediment from the site would initially be required in order to implement this option (i.e., dredging with transport to Holnam). PCB hot spot sediments with concentrations above 20 ppm dry weight would not be accepted at this facility. This disposal option is being carried forward for further evaluation.

Thermal Treatment (Portable Thermal Plants). These facilities will reduce organic concentrations but are not applicable to heavy metals. Removal of the sediment from the site would initially be required in order to implement this option (i.e., dredging with transport to thermal plant). There is a high cost for mobilization and treatment of wet sediments. Based on the above, this option has been eliminated from further evaluation.

Thermal Treatment (Lightweight Aggregate from Dredged Sediments). This thermal treatment process is essentially the same process used at Holnam Inc., except that the rotary kiln would be located on a barge which is operating at the dredging site. Removal of the sediment from the site would initially be required in order to implement this option (i.e., dredging then transport to LADS plant). As discussed earlier, the rotary kiln process will either immobilize and/or destroy contaminants during the process of producing lightweight aggregate. To date, the prototype for this system has not been produced, therefore it must be considered as experimental. Because of its limited history, this would be a difficult technology to permit. The capital and testing costs associated with building a plant to implement this option are large. This option is eliminated from further evaluation based on the above.

Thermal Treatment (Incineration). This option has been proven effective but typically has not been used for dredging projects. Removal of the sediment from the site would initially be required in order to implement this option (i.e., dredging then transport to incineration plant). There are no known permitted incinerators in the Northwest which could be used. Constructing and permitting a new incinerator is not cost effective for the small volumes involved in this project. Based on the above, this option has been eliminated from further evaluation.

7.2.5 Containment Options

Applying the screening criteria to containment options yields the following results:

In Situ Capping (Thick Layer). This option involves placing a cap, typically composed of clean sand, over the contaminated footprint within the project site. The depth of the cap typically is equal to or greater than three feet in thickness. This cap is used to isolate the contaminated sediment from the water column and from the biologically active zone of the sediments. While this option is technically effective in a low energy aquatic environment, its effectiveness (i.e. stability) in a river intertidal system is significantly diminished due to potential high current velocities that occur during storm events. A thick cap option is also not considered a permanent option for this site. No significant logistical construction impacts are foreseen. This option may also be difficult to permit; contaminated sediment is left on site which conflicts with both Ecology and DNR preference for removal. Other permitting issues include potential adverse impacts to fishery habitat due to capping of the mudflat. This option would be cost effective for initial implementation; however, maintenance and monitoring costs would be high. This option is eliminated based on reasons stated above.

In Situ Capping (Thin Layer). This option is commonly referred to as enhanced natural recovery. A thin cap, typically composed of clean sand and with a thickness less than three feet, is placed over the contaminated footprint within the project site. The cap acts to dilute the concentration of contaminants available to the water column. Bioturbation acts to mix the clean upper sediments with the contaminated lower sediments. Over time, the contaminant concentrations can decrease, if the site conditions allow and there is no source of recontamination. This option can be technically effective if contaminant sources are eliminated or reduced and initial sediment contamination is low. However, the timeframe for enhanced natural recovery cannot be predicted with the data available for this site. Also, the ability to adequately decrease concentrations to appropriate levels is unknown. As stated in thick layer capping, cap stability in a river intertidal environment is probably not effective. Contaminated sediment is left on the site, which conflicts with Ecology and DNR preference for removal. No significant logistical construction impacts are foreseen, and costs would be relatively low. Future costs would probably only include monitoring. This option is eliminated based on reasons stated above.

In Situ Capping (Inverted). Inverted capping involves removing the top layer of contaminated sediment and stockpiling on site, then removing enough clean underlying material to be able to place the contaminated material into this deeper excavated area. After the contaminated material is backfilled, the clean sediment is placed on top as a cap. This option has not been extensively used and rarely utilized in the Northwest. Permitting this option may be difficult. Contaminated sediment would remain on-site and not be removed, thus conflicting with Ecology and DNR preference for removal. Logistics during construction for this option are significantly more difficult than other capping options due to the dredging and stockpiling component. This option is eliminated based on the above reasons.

Confined Aquatic Disposal. Confined aquatic disposal (CAD) has basically the same function as thick layer capping, except that contaminated sediment is first dredged, then moved to the disposal site prior to capping. The objective is to isolate the contaminated sediment from the water column. A CAD site is typically found in deeper water and would probably need to be located in Elliott Bay if this option were to be feasible. Contaminated sediment is placed on the existing bottom then covered with clean cap material to isolate the contaminants from the water column and marine organisms. CAD sites are technically effective in areas with flat slopes or depressions, low energy environments, and no fishing access or navigational constraints. However, the Elliott Bay vicinity typically does not have good locations for CAD sites. CAD sites in the Elliott Bay vicinity are very difficult to implement and permit; one reason is navigation requirements in the Duwamish Waterways and Elliott Bay. Cost to engineer and construct a stable CAD site in Elliott Bay is high and would take several years, delaying the Norfolk cleanup schedule. This option is eliminated based on the above reasons.

Nearshore Confined Disposal. This option typically involves construction of a confined disposal facility located in the nearshore region, typically within the intertidal zone. A berm is constructed to provide capacity to place the contaminated material. A clean cap is then placed over the material to isolate the contaminants. This option has been used on several Northwest projects and has been proven effective. However, King County, the City of Seattle, and other

Panel members have no known development plans within the next few years which include need for new land for commercial water-dependent purposes in the Elliott Bay/Duwamish Waterway vicinity, that could potentially be used for nearshore confined disposal. Use of waterfront development projects by other parties would have multiple and complex liability issues that would need to be resolved. Without the above project in place, permits are very difficult to secure. This option is relatively cost effective to construct. However, much additional research, engineering, and permitting would be required to implement this option. These costs would be much higher than other options; additionally, the process would take several years to complete, delaying the Norfolk cleanup schedule. Based on the above reasons, this option is eliminated.

RCRA Subtitle D Landfills. This option is proven technology and relatively straightforward to permit. Costs for disposal at these facilities are comparable to other containment options and are fairly well defined. The Norfolk contaminated sediment has been tested for waste characteristics (**Appendix K**). The testing indicates that all of the sediment is non-hazardous except for a small volume associated with one PCB hot spot which would be disposed at a hazardous waste landfill. This option is carried forward.

Hazardous Waste Landfill (Arlington). This option is proven technology and relatively straightforward to permit. The Norfolk contaminated sediment has been tested for waste characterization (**Appendix K**). The testing indicates that all of the sediment is non-hazardous except for a small volume associated with one PCB hot spot which would be disposed at this facility. Therefore, this option is not cost effective <u>except</u> for the PCB hot spot material. This option is carried forward.

Municipal Landfill Closure Material. Technical effectiveness of this option is unknown. Significant additional evaluation of the sediments and of the specific landfill closure site would be required to determine the effectiveness of this option. However, since there are currently no identified closure sites, this option is not presently implementable. Agency acceptance of this option is unknown. This option is eliminated based on the above reasons.

Miscellaneous Upland Disposal Locations. There are no currently identified available sites at this time. Significant further investigation and evaluation would be required for any available site to determine whether the disposal site would be technically effective in containing the contaminated sediment. This option would be difficult to permit since it is not proven, and any potential disposal site may be unfamiliar to local agencies. Based on the above reasons, this option is eliminated.

Construction Backfill. Substantial study would be required to assure that disposal procedures are safe and that the disposal site would be technically effective in containing the contaminated sediment. Concentrations of pollutants would have to be below the MTCA cleanup levels to allow disposal without institutional controls. Review of data indicates that concentrations are greater than allowable. This option would also be difficult to permit. Based on the above reasons, this option is eliminated.

A summary of the screening of technologies and process options is presented in **Table 7-1**. Due to the limited volume of contaminated sediments to be remediated at the Norfolk Site, a permanent solution entailing excavation of sediments followed by offsite treatment or disposal is clearly achievable. For all aquatic and upland site cleanup projects, a permanent solution when achievable is clearly preferred by resource agencies. The hydraulics of the river system, in which storm scour can re-expose containment systems, further supports a permanent solution based on removal. This general argument supports elimination of capping, aquatic disposal and other containment technologies from further consideration.

Table 7-1
Technologies and Process Options Summary

Options	Technical Effectiveness (Does the option appear to have merit?)	Implementability (Is the option feasible?)		Relative Cost (low, medium, high)	Adverse Impacts (Does the option have significant adverse impacts?)	Comments
		Logistics	Regulatory			
No Action	No.	Yes.	No. PCB hot spots would be left in place.	Low.	Yes. PCB hot spots would be left in place.	This option is carried forward as a basis for alternatives comparison.
Natural Recovery	No. Time required for natural recovery cannot be predicted.	Yes.	No. Conflicts with DNR and MTCA preference for removal	Low.	Yes. PCB hot spots would be left in place.	Unknown time frame for recovery. Conflicts with EBDRP desire for removal.
Mechanical Dredging	Yes. Proven technology.	Yes. Dredging would probably occur from the water rather than shore-based.	Yes. Proven technology.	Medium.	No. Dredging will suspend some sediment in the water column, but this is a short term impact and is controllable.	Proven technology. Sampling indicates that depth of contaminated sediment is small enough to remove all contaminated sediment. Logistics are dependent on staging area and treatment/disposal site selected.
Hydraulic Dredging	Yes. Proven technology.	Yes. Assuming dewatering in a barge with direct discharge from the barge is allowable.	Yes. Proven technology.	Medium.	No. Dredging will suspend some sediment in the water column, but this is a short term impact and is controllable.	For small volumes, hydraulic dredging typically has higher costs and is more complicated to plan and permit than mechanical dredging.
Bioremediation	No. Not very effective on heavy metal contaminants and PCBs. Extensive research would be required for effective bioremediation.	No. Extensive material handling and working.	No. Largely untested for dredging projects	High. Undefined costs.	Unknown; biodegradation of PCB and 1,4-DCB could produce more mobile and available degradation products, whose toxicity is unknown.	Costs to test and prove this technology are high. This option would need to be combined with excavation to make it feasible.

Table 7-1 (continued)

Options	Technical Effectiveness (Does the option appear to have merit?)	Implementability (Is the option feasible?) Logistics	Implementability (Is the option feasible?) Regulatory	Relative Cost (low, medium, high)	Adverse Impacts (Does the option have significant adverse impacts?)	Comments
Soil Washing	Maybe. However, this option has not been applied to dredging projects and success is questionable with both heavy metal and organic contamination.	Yes. Combined with excavation.	No. Little track record	High. Undefined costs.	No.	Due to high mobilization costs, this option has potential for large projects. Pilot scale studies would be required to prove the technical effectiveness.
Thermal-Holnam, Inc.	Yes. Proven technology	Yes. Sediments may be wetter than as acceptable under other thermal options.	Yes. Approval for treatment can normally be secured concurrent with other permitting processes.	Medium. $40 - $50/cy. Cost does not include transportation to the site.	No.	Contaminants are destroyed or immobilized by the treatment. Bulk chemistry, TCLP, and minerals analyses are required.
Portable Thermal Plants	No. This option is not applicable to heavy metals; especially mercury which creates air emission problems.	Yes.	No. May be difficult to permit due to little track record.	High. Undefined costs.	No.	These facilities will reduce organic concentrations but are not generally applicable to heavy metals. There is a high cost for mobilization and treatment
LADS	Yes. However, there is no existing plant.	Yes.	No. New technology. May be difficult to permit due to little track record.	High. Undefined costs.	No.	Essentially the same process as Holnam, except rotary kiln is on a barge. No existing plants.
Incineration	Yes.	No.	No. May be difficult to permit due to little track record.	High. Undefined costs.	No.	No known available incineration plants in the Northwest.
In Situ Thick Cap	No. Cap stability is suspect in a river environment.	Yes.	No. Probable difficulty securing permits due to concern about cap stability.	Low - Medium.	Possible. A thick cap (i.e., >3 feet) may cause change in the flow regime and loss of fish habitat.	There are difficulties in predicting cap stability in this hydrodynamic environment. Contaminated sediment would remain on site conflicting with DNR and MTCA preference for

Table 7-1 (continued)

Options	Technical Effectiveness (Does the option appear to have merit?)	Implementability (Is the option feasible?) Logistics	Implementability (Is the option feasible?) Regulatory	Relative Cost (low, medium, high)	Adverse Impacts (Does the option have significant adverse impacts?)	Comments
						removal.
In Situ Thin Layer Cap	Possible. Cap stability is suspect.	Yes.	Unknown. Concerns are cap stability and effectiveness of capping to enhance natural recovery.	Low.	No.	Additional study would likely be required to demonstrate that enhanced natural recovery at this site would be effective. Hydrodynamics of the site may need to be modeled.
In Situ Inverted Cap	Yes. Effective if depth of contamination is known to allow for design.	Yes. If depth of contamination is less than about 2 to 3 feet.	Unknown. Little track record.	Medium.	No.	Logistics are significantly more difficult than other capping options plus contaminated sediment would remain on the site.
Confined Aquatic Disposal	Yes.	No. Location for CAD site would be difficult to find.	No. CAD sites in Elliott Bay are difficult to permit.	High.	Yes. Navigation and fishing access impacts.	Costs to design and construct a stable CAD site is high in Elliott Bay. Locating an appropriate site would be difficult.
Nearshore Confined Disposal	Yes.	No. No known nearshore development projects in the area that are already approved and have acceptable long-term liability to the Panel	No. Difficult to permit without an identified nearshore development site.	Medium.	Yes. Loss of intertidal habitat and/or navigation depths at the NCD site. Fishing access impacts.	It does not appear that this option is implementable at this time due to a lack of nearshore development projects within the next several years.
RCRA Subtitle D Landfill	Yes. Proven technology.	Yes.	Acceptability of sediment based on sediment testing results and negotiation with landfill	Medium. \$40 - \$50/cy. Includes tipping fee, rail transport from Seattle to landfill	No.	Most landfills have good rail transport. Bulk chemistry, TCLP, Paint filter, and fish bioassays are required. Number of samples per volume is project specific.

Table 7-1 (continued)

Options	Technical Effectiveness (Does the option appear to have merit?)	Implementability (Is the option feasible?)		Relative Cost (low, medium, high)	Adverse Impacts (Does the option have significant adverse impacts?)	Comments
		Logistics	Regulatory			
Arlington Hazardous Waste Landfill	Yes. Proven technology.	Yes.	Acceptability of sediment based on sediment testing results and negotiation with landfill	High. $300 plus/cy	No.	Material dewatering and then placement in sealed barrels or confined tuckload. Haul and dispose of barrels at Arlington. Use only for PCB material >20 mg/Kg DW.
Municipal Landfill Closure Material	Yes. Proven technology.	No.	Unknown acceptability.	Unknown.	Unknown.	No sites are currently identified. Negotiations and feasibility studies are needed to implement.
Miscellaneous Upland Disposal Locations	Unknown.	No.	No.	Unknown.	Unknown.	No sites are currently identified. Significant time would be required to identify and then permit the facility.
Construction Backfill	Yes. Provided site specific criteria are met.	No. Project specific analyses required.	No. Process would be intensive.	Unknown. Project specific.	Unknown.	Substantial study is required to assure that disposal procedures are safe and material does not trigger an upland cleanup action. No on-site land is identified as available.

8.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

Following initial screening, the technology types and process options retained for screening and development of alternatives are:

- No Action
- Excavation
  - Mechanical Dredging
  - Hydraulic Dredging
- Treatment
  - Holnam Cement Plant (Thermal treatment)
- Upland Disposal
  - RCRA Subtitle D Landfills
  - Arlington Hazardous Waste Landfill (PCB hot spot sediments only)

The objective of this chapter is to assemble, screen, and develop alternatives that will undergo detailed evaluation. These alternatives are assembled from all potential combinations of the technologies and process options that remain after initial screening in **Chapter 7**. After the alternatives are assembled, a secondary screening is applied based on criteria of technical effectiveness, implementability, cost, and adverse impacts. A conceptual design is then developed for each remaining alternative in order to perform a detailed evaluation in **Chapter 9**.

8.1 ASSEMBLY OF ALTERNATIVES

Utilizing the above technology and process options, the following alternatives are assembled which have potential for implementation and further evaluation:

- No action
- Mechanical dredging with upland disposal at RCRA Subtitle D Landfill
- Mechanical dredging with treatment at Holnam
- Hydraulic dredging with upland disposal at RCRA Subtitle D Landfill
- Hydraulic dredging with treatment at Holnam

The No Action alternative is carried forward to provide comparison with the other alternatives.

8.2 SCREENING OF ALTERNATIVES

The individual handling, treatment, and disposal option components were screened in **Chapter 7.2** in order to eliminate those technologies and/or process options not considered feasible. The next step is to evaluate the assembled alternatives against each other with respect to the screening criteria below:

- **Technical effectiveness.** Will the alternative effectively cleanup the site?
- **Implementability.** Is the alternative clearly not permittable or does it appear to have significant difficulty in permitting? Does the site have significant logistical problems for construction?
- **Cost effective.** What is the relative cost of each alternative? Alternatives with high relative costs should be screened out.
- **Adverse impacts.** Alternatives that may cause significant (i.e. not easily mitigated) adverse impacts should be screened out.

8.2.1 PCB Hot Spot Removal

Sediments from the PCB hot spot at station 315 (19,000 mg/kg OC or 478 mg/kg DW) exceed the TSCA criteria of 50 mg/kg DW, and will be treated as hazardous materials. They will be dredged separately and disposed at Arlington Hazardous Waste landfill. Arlington could also be used for sediments exceeding the upper PCB limit for Holnam (20 mg/kg), to avoid hauling sediments to three different treatment/disposal locations. Removal and disposal of PCB hot spot sediments will be treated as a distinct step that precedes the other cleanup options. Each alternative, except the No Action alternative, will include PCB hot spot removal prior to proceeding with the remedial action. Confirmational sampling will be performed to ensure all TSCA-regulated sediments have been removed.

8.2.2 Alternative 1: No Action

Alternative 1 would not implement any remedial actions. The site would remain as is and no institutional controls would be implemented Although this alternative may not be technically effective, it is being carried forward as a basis for alternatives comparison.

8.2.3 Alternative 2: Mechanical Dredging with Upland Disposal at a Subtitle D Landfill

Alternative 2 employs proven and accepted technologies. Permitting for this alternative would be relatively straightforward and similar to all of the other alternatives. For small volumes, mechanical dredging typically has a lower unit cost than hydraulic dredging. The main reason for the lower cost typically involves handling less water. Disposal costs are approximately the same at any Subtitle D Landfill. PCB hot spot removal will occur before this alternative and will have the same costs for Alternatives 2 through 5. No significant adverse impacts are foreseen. Based on the above, this alternative is carried forward for detailed evaluation.

8.2.4 Alternative 3: Mechanical Dredging with Treatment at Holnam

Alternative 3 is similar to Alternative 2; the only difference is that contaminated sediment (excluding the PCB hot spot sediments) will be transported to Holnam, Inc., for treatment instead of upland disposal. Treatment costs at Holnam are comparable to upland disposal costs, and treatment of the contaminated sediments will destroy the contaminants within the sediment. Removal of the PCB hot spot will have the same costs as for Alternatives 2 through 5. No significant adverse impacts are foreseen. Based on the above, this alternative is carried forward for detailed evaluation.

8.2.5 Alternative 4: Hydraulic Dredging with Upland Disposal at a Subtitle D Landfill

Alternative 4 employs proven and accepted technologies. Permitting for this alternative would be relatively straightforward and comparable to all of the other alternatives. For small volumes, hydraulic dredging typically has a higher unit cost than mechanical dredging. The primary reason for the cost difference is due to the fact that hydraulic dredging involves the movement of large quantities of water, necessary to create a slurry to transport the dredged sediment. This large quantity of water needs to be removed and treated before sediment disposal. Sediment dewatering costs are typically significantly greater than for mechanical dredging.

There are two options for temporary storage and dewatering of the slurry. The first option is to construct an upland storage/dewatering area, such as an enclosed diked area. The slurry would be pumped into this area to allow settling of suspended solids and dewatering of the material. Due to the intensiveness of upland activities and uses in this area, an upland site would be very difficult to locate, permit, and construct adjacent to the dredging site. This first option is cost prohibitive and would be difficult to implement. The second option would be to pump the slurry into a barge. The slurry would be allowed to settle, then the supernatant water would be pumped off the barge through some manner of filter system to prevent suspended sediment from being discharged to the receiving water. After adequate dewatering, the sediment would be removed from the barge and transported to the upland disposal site. Dewatering of hydraulically dredged material will require more time than for mechanically dredged sediment. This option may be cost effective for this site.

Disposal costs are approximately the same at any Subtitle D Landfill. PCB hotspot removal will occur before this alternative and will have the same costs for Alternatives 2 through 5. No significant adverse impacts are foreseen. Based on the above reasons, this alternative, assuming that a barge dewatering site is used, is carried forward for detailed evaluation.

8.2.6 Alternative 5: Hydraulic Dredging with Treatment at Holnam

Alternative 5 is similar to Alternative 4; the only difference is that contaminated sediment (excluding the PCB hot spot material) will be transported to Holnam Inc. for treatment instead of upland disposal. This option may be feasible since Holnam can handle both wet and dry material. Sediment would still need to be dewatered within the barge before treatment at Holnam, but would not require as much dewatering as needed for upland disposal. Treatment costs are comparable to upland disposal costs, and treatment of the contaminated sediment destroys contaminants within the sediment. PCB hot spot removal will have the same cost for Alternatives 2 through 5. No significant adverse impacts are foreseen. Based on the above reasons, this alternative is carried forward for detailed evaluation.

8.3 DEVELOPMENT OF ALTERNATIVES

After screening of the alternatives, the evaluation indicates that all of the alternatives are feasible and comparable with each other. No alternative has any criterion that fully eliminates it from further detailed evaluation. However, partial screening to eliminate an upland dewatering site did occur with Alternatives 4 and 5. To prepare a detailed evaluation, it is first necessary to provide a conceptual design for purposes of evaluation and comparison against other alternatives. The conceptual design must make many assumptions due to lack of information on key issues. Issues needing better definition include: location of upland staging area(s), equipment selection, and specific permitting requirements. For this analysis, we have assumed the following:

- <u>Upland sites within the Duwamish Waterway will be available for use as staging areas and rehandling areas</u>. Presently no upland sites have been identified for construction use. There will be requirements for the upland sites such as easy access to the Duwamish Waterway, ability to transfer equipment to and from the site, and sufficient size to accommodate all operations. Typically, an existing dock would allow the above. Other issues that would need to be resolved for the site include indemnifying and holding harmless the owner of the site from potential claims, and cleaning up the site to original conditions after the project was completed.
- <u>Discharge of effluent water from the barge for the hydraulic dredging alternatives will be allowed</u>. During the design phase, elutriate testing will be required to determine the suitability of discharging effluent to the river. Due to the generally low concentrations of contaminants, it is expected that this discharge will be allowed without treating the supernatant (effluent). As discussed previously, the cost to construct an upland dewatering site for hydraulic dredging is prohibitive, therefore hydraulic dredging can feasibly occur <u>only</u> if dewatering on the barge is permitted.
- <u>Fairly small equipment will be used for this project</u>, either mechanical or hydraulic. Smaller equipment will have lower mobilization cost but will require more construction time to complete the project. Access to the Norfolk site is limited both by the downstream concrete bridge and by steep banks with medium to dense vegetation cover on top of the bank.

- For the alternatives with treatment at Holnam, it is assumed that dewatered material will be trucked to the facility. This assumption is based on Holnam's preference for trucked material. Holnam has existing facilities that could offload material from the barge directly, which would result in significant cost savings. This issue should be further explored with Holnam prior to detailed design. It is also assumed that the material will be acceptable for use by Holnam. Preliminary evaluation (**Appendix K**) indicates that the material will meet criteria for Holnam (Lahaie, 1996).

These assumptions allow us to complete an initial conceptual design for further detailed analyses. The conceptual designs of alternatives are described below.

8.3.1 PCB Hot Spot Removal

All remedial alternatives (Alternatives 2, 3, 4, and 5) will require removal of the sediments at the PCB hot spot (Station 315) for disposal at the hazardous waste landfill at Arlington, Oregon. A 1994 survey of local RCRA Subtitle D municipal landfills showed that soils and sediments with PCB concentrations greater than 50 mg/kg DW will not be accepted. The PCB concentration at Station 315 was reported as 478 mg/kg DW. Assuming a 50x50 foot area around the hotspot, and a dredging depth of 3 foot (i.e., average 2-foot depth of contamination plus 1 foot overdredge), results in a conservative estimate of 300 cubic yards for the total volume of sediments with PCB contamination greater than 50 mg/kg.

Under all remedial alternatives discussed in the following subsections, this sediment would be removed prior to removing all other contaminated sediments. Sampling would be performed prior to dredging to define the extent of the hot spot. The dredge would be located at Station 315 and sediment to a depth of 3 feet would be removed from the site. Representative samples would be collected and analyzed. Confirmational sampling would occur to ensure no sediments with PCB concentrations greater than 50 mg/kg remain. Additional sediment would be removed, as necessary. These sediments would be disposed of at the hazardous waste landfill in Arlington, Oregon.

This activity will be common to Alternatives 2, 3, 4, and 5. Projected costs are based on the conservative estimate of 300 cubic yards to be removed.

8.3.2 Alternative 1: No Action

Under this alternative, no remedial action would occur. The site would remain as is. No institutional controls would be implemented, no long-term monitoring would occur, and the PCB hot spot would not be removed. Monitoring of the Norfolk CSO outfall as required for NPDES permits or other programs would occur as normal. This alternative is carried forward for comparative purposes.

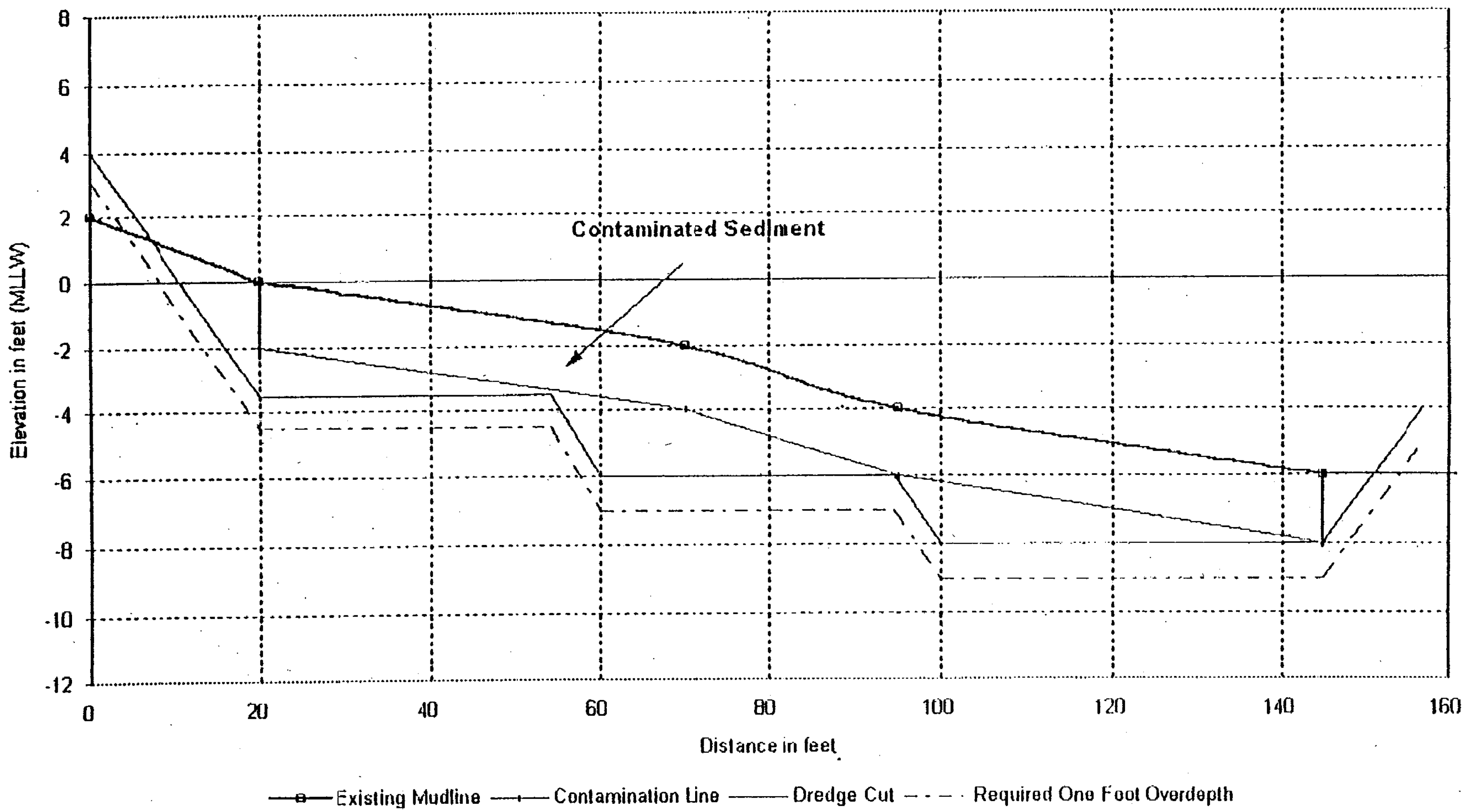
8.3.3 Alternative 2: Mechanical Dredging with Upland Disposal at a Subtitle D Landfill

Mechanical dredging is accomplished using a clamshell dredge from a floating barge. Dredging can take place using a crane with clamshell from the shore if the crane has sufficient reach to dredge the sediment. For this site, the area to be dredged is located on the east side of the Duwamish River, which has limited access due to a covered walkway structure, steep bank slopes, and medium to dense vegetation cover. Therefore, dredging would be most effective from a floating barge.

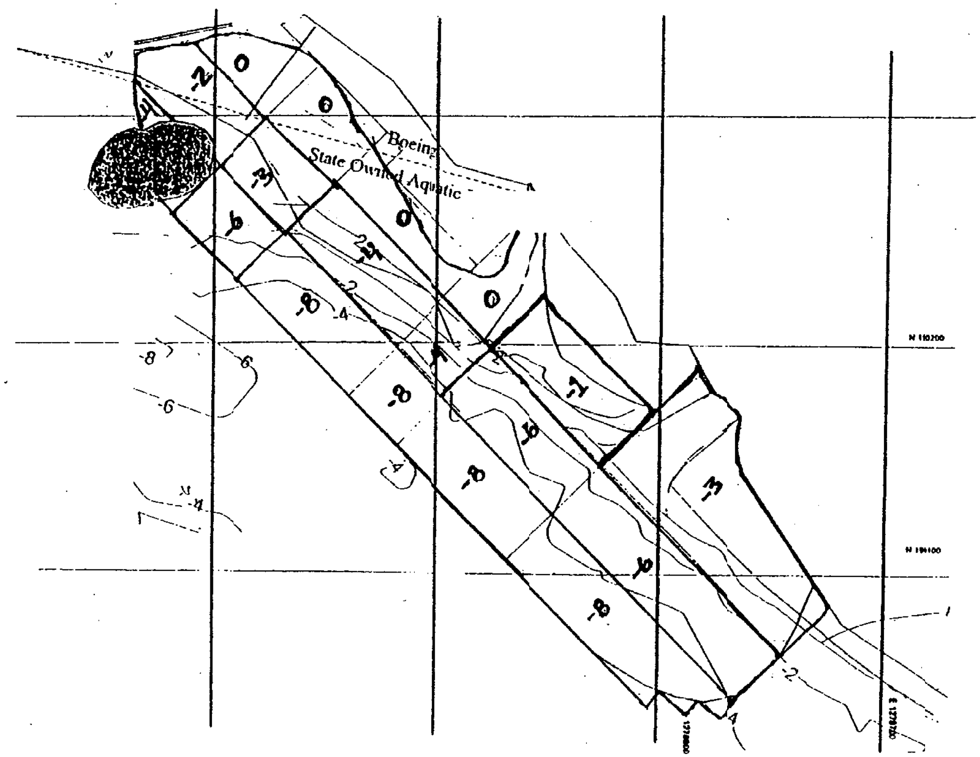
Sediment will be excavated from the dredge footprint in a stair step manner (**Figure 8-1**). Dredging equipment will make horizontal cuts into the sediment. Since the dredging area is on a slope, these horizontal cuts will run parallel along the shore to a designed depth and width. Cuts shoreward or channelward will also be at various depths and widths depending upon bathymetry and equipment reach. Typically, a contractor will lay out a grid in the plan view showing the depth that the dredge will excavate to in individual areas (**Figure 8-2**). Because the dredge cannot cut along a slope, the depth of material removed will vary from a minimum cut which is at or below the bottom elevation of contamination (i.e., for this project, the minimum cut will be approximately 2 feet thick), to a maximum cut which can be several feet thicker than the minimum cut. The required depth of dredging is the minimum depth that will remove all contaminated material. Because of equipment tolerances, one foot of overdepth at a minimum is required to ensure that all material above the required dredging cut is removed. The preliminary volume to the required dredge cut line is approximately 6,000 cubic yards. However, the actual volume that will be removed is based on the required dredge cut depth plus one foot of overdepth. The preliminary total volume to be dredged for this project including one foot of overdepth is approximately 7,200 cubic yards. Using a 5% swell factor, the total bulked volume of sediment is 7,600 cubic yards.

There is approximately 20 feet of clearance under the downstream bridge at Mean Lower Low Water (MLLW). This is sufficient clearance to bring in some smaller dredge equipment. Larger equipment may have to be transported upstream of the bridge via land and then reinstalled onto the barge. A 2 to 3 cubic yard clamshell bucket will most likely be used based on the small volumes and shallow dredge cuts.

A second barge will be used for disposal and will be tied up to the clamshell barge. After this second barge is filled to capacity, it will be taken downstream to an undesignated upland rehandling site. The barge will be moved using both workboats and a tugboat. Upland site(s) will need to be identified for either a staging area or rehandling/stockpiling area. The supernatant water would be pumped out through a system of filters, if results of elutriate testing performed during the design phase are satisfactory. Sediment will then be offloaded to a stockpile area, or rehandled directly into lined trucks, and hauled to the transfer station where rail cars will be loaded. Stockpiling of the sediment may be necessary if further dewatering of the sediment is required. Since there is a high percentage of coarse particles (i.e., sand) within the dredge area, more complicated and expensive dewatering methods are not expected to be required. After the material is rehandled onto lined train cars, it will be transported to a fully permitted Subtitle D Landfill for disposal.



EcoChem Team	Norfolk Sediment Cleanup Study Representative Cross-Section and Dredge Cuts	Figure 8-1



EcoChem Team	Norfolk Sediment Cleanup Study Representative Plan View of Dredge Cuts	Figure 8-2

8.3.4 Alternative 3: Mechanical Dredging with Treatment at Holnam

This alternative would use the same dredging equipment as described in Alternative 2. Although Holnam has the capability to offload material from barges, they prefer that material is brought in by truck. If material is transported by truck, a rehandling area (similar to Alternative 2) would be required to transfer material from the barge to lined trucks. Stockpiling of the material for additional dewatering would not be necessary since Holnam can accept relatively wet material.

8.3.5 Alternative 4: Hydraulic Dredging with Upland Disposal at a Subtitle D Landfill

Hydraulic dredging involves entraining sediment and water into a slurry, to allow transport of the sediment through a pipeline which discharges into a barge or upland storage area. A typical slurry concentration is approximately 15% solids by weight. Therefore, the amount of water entrained is much greater than the amount of sediment dredged. Since access to this site is limited, a fairly small sized hydraulic dredge would likely be used. Since hydraulic dredging to an upland storage site was determined to be not feasible, discharge into a barge will be required. The barge could be positioned downstream of the concrete bridge if clearance is a problem. Clearance under the concrete bridge for a small hydraulic dredge is not a concern. As discussed for Alternative 2, the dredging plan will be based on a stair step method. Sediment volumes excavated by hydraulic dredging will be approximately the same as for mechanical dredging.

A typical barge used for hydraulic dredge discharge is a dumpscow. This barge has compartments and drainage holes within to allow settling of the suspended sediments and dewatering of the material. After the barge is filled to capacity with slurry (with no overflow), the contractor would wait for the suspended sediment to settle out. The supernatant water would be pumped out through a system of filters, if results of elutriate testing performed during the design phase are satisfactory. After the effluent water is discharged, the sediment would be stockpiled at the upland dewatering area for further dewatering, or rehandled directly into lined trucks for transport to the transfer station for rail car loading. Since there is a high percentage of coarse particles (i.e., sand) within the dredge area, more complicated and expensive dewatering methods are not expected to be required. After the material is rehandled onto lined train cars, it will be transported to a fully permitted Subtitle D Landfill for disposal.

8.3.6 Alternative 5: Hydraulic Dredging with Treatment at Holnam

This alternative would use the same dredging and dewatering process as described in Alternative 4. Material could be offloaded from the barge into lined trucks. Stockpiling of the material for additional dewatering would not be necessary since Holnam can take relatively wet material.

9.0 DETAILED EVALUATION OF ALTERNATIVES

In **Chapter 8.0**, technology and process options were assembled into Alternatives and were screened using the threshold criteria of technical effectiveness, implementability, cost effectiveness, and adverse impacts. In this chapter, the alternatives are evaluated in detail against eight criteria presented in WAC 173-204-560(4)(f)(iii). These criteria include:

1. Overall protection of human health and the environment by eliminating, reducing, or otherwise controlling risks posed through each exposure pathway and migration route.
2. Compliance with cleanup standards and applicable federal, state, and local laws.
3. Short-term effectiveness, including protection of human health and the environment during construction and implementation of the alternative.
4. Long-term effectiveness, including degree of certainty that the alternative will be successful, long-term reliability, magnitude of residual human health and biological risks, effectiveness of controls for ongoing discharges, management of treatment residuals, and disposal site risks.
5. Ability to implement, including the potential for landowner cooperation, technical feasibility, availability of disposal facilities, administrative and regulatory requirements, monitoring requirements, access needs, operation and maintenance, and integration with existing operations.
6. Cost, including consideration of present and future direct and indirect capital, operation and maintenance costs, and other foreseeable costs.
7. The degree to which community concerns are addressed.
8. The degree to which recycling, reuse, and waste minimization are employed.

This chapter concludes with a comparison of the alternatives and the selection of the preferred alternative.

9.1 ALTERNATIVE 1: NO ACTION

The No Action alternative is included as a baseline alternative by which other alternatives can be compared. Under this alternative, the site remains unchanged, and nothing is done to mitigate existing impacts to human health and the environment. No source control measures are implemented beyond those currently planned. In the absence of ongoing sources, gradual improvement in the level of contamination at the site would be expected. This improvement would occur through deposition of clean sediments, degradation of contaminants by chemical, physical, and biological processes, and migration of contaminated sediments downstream and out into Elliott Bay. It is not possible to determine a time frame for achieving remedial goals.

9.1.1 Overall Protection of Human Health and the Environment

This alternative will not provide protection of human health and the environment in a timely manner because no remedial action would be performed.

9.1.2 Compliance with Cleanup Standards and Applicable Laws

This alternative does not comply with cleanup standards or applicable laws since contamination would remain exposed on site at concentrations above the minimum cleanup level for an unacceptable time period. There would be no reduction of the threat to the environment.

9.1.3 Short-Term Effectiveness

Since there is no remedial action, short-term effectiveness does not apply.

9.1.4 Long-Term Effectiveness

Since no contamination in the sediments is removed, capped, or treated, the long-term risk would remain essentially unchanged. Many of the contaminants (e.g., PCBs and mercury) are persistent and are not expected to attenuate to acceptable levels.

9.1.5 Implementability

There are no actions to implement under this alternative.

9.1.6 Cost

There is no cost associated with this alternative.

9.1.7 Community Concerns

It is not possible to evaluate the community's concerns regarding this alternative until after the public comment period. The public comment period will extend for a 30-day period during which the public will be asked to provide their evaluation, advice, and any concerns they have regarding all potential alternatives.

9.1.8 Employment of Recycling, Reuse, and Waste Minimization

There is no use of recycling, reuse, or waste minimization practices in this alternative since no remedial action would occur.

9.2 ALTERNATIVE 2: MECHANICAL DREDGING WITH UPLAND DISPOSAL

Under this alternative, contaminated sediments would be removed using a mechanical clamshell dredge located on a barge; dewatered in the barge or in lined, leak-tight trucks or rail cars; stockpiled on an adjacent barge or at an upland location; and transported to an appropriate landfill. Some of the sediments may require disposal in a hazardous waste landfill, while most sediments would be disposed of in a Subtitle D municipal landfill. No long-term monitoring will be required since all contamination will be removed from the site. Confirmational monitoring and monitoring of the Norfolk outfall conducted under an NPDES permit would still be required.

9.2.1 Overall Protection of Human Health and the Environment

This alternative will provide protection of human health and the environment by removing all contamination at levels greater than the SQS (or below SQS for PCBs) from the site. These contaminated sediments would be relocated to an appropriate landfill, where they would be isolated from human contact and would be contained in isolation from the environment. Engineering controls would be instituted during the dredging and dewatering operation to ensure dredged materials are properly contained and disposed of.

9.2.2 Compliance with Cleanup Standards and Applicable Laws

This alternative would comply with cleanup standards and all applicable laws. Water quality permits would be obtained and measures would be implemented to ensure that water quality is not degraded during dredging and dewatering operations. The dredged sediments would be placed in an appropriate, fully permitted landfill. All required permits would be obtained prior to performing the remedial activities.

9.2.3 Short-Term Effectiveness

The dredge and upland rehandling sites would present a low risk to the public because there would be no access allowed to these areas. Since the sediments would be transported by trucks or rail cars to the landfill, there is a limited potential for public exposure to the sediment by leakage or accidents during transport. There is high risk for possible direct sediment contact by workers, especially during rehandling from the barge to trucks or rail cars, and during rehandling from a temporary stockpile/dewatering site to trucks or rail cars. Health and safety procedures would be required to protect workers during these operations.

Dredging of the sediments could create limited adverse water quality impacts at the dredging site. Raising and lowering the clamshell bucket can cause sediment suspension and suspended contaminants can be moved by river currents, thus spreading contamination. If this resuspension and turbidity occurs at levels of concern, it could be controlled by using special clamshell buckets designed specifically to reduce releases of contaminated sediments, and/or by the use of silt curtains or air curtains to limit the migration of suspended sediments. Because there is a high percentage of sand at the Norfolk site, the majority of suspended sediments would settle rapidly at the project site, and these additional silt control measures may not be required.

9.2.4 Long-Term Effectiveness

All designated contaminated sediments would be removed from the site. Most contaminants would be placed in a municipal landfill which conforms with RCRA Subtitle D. Some sediments may require disposal in a hazardous waste landfill. These landfills are designed to prevent contaminants from leaching to the environment. These removal and disposal procedures ensure long-term effectiveness of the remedy.

9.2.5 Implementability

This alternative is readily implementable. Mechanical dredging and accessory equipment is available locally and is a reliable, proven technology. Permits need to be obtained; however, this is a relatively straightforward process and the technology is accepted. Constraints at the Norfolk site pose some potential logistical problems for a contractor. These constraints include an existing concrete bridge immediately downstream of the Norfolk site, steep banks on both sides of the Duwamish River, medium to dense vegetative cover at the top of both banks, and an existing covered walkway on the east bank of the site.

Clearance under the concrete bridge may pose problems during mobilization of equipment to the site, and during transport of the barge to and from an upland rehandling site. Bridge clearance is approximately 20 feet at Mean Lower Low Water (MLLW). A typical barge that may be used for this project draws approximately three to four feet when empty with a freeboard of approximately eight to twelve feet. There should be sufficient bridge clearance for barge movement, but would be dependent on draft of the barge and stage of the tide. The rest of the dredging equipment, including crane and clamshell, would have difficulty in clearing the bridge at higher tides but may clear the bridge at low tides. Another option is to mobilize the crane upland and assemble the dredge upstream of the bridge. An upland staging area would be required to load the dredging equipment onto the barge.

Dredged sediment would be temporarily deposited into a second barge which would be offloaded at an upland rehandling site (i.e., possibly the same site as the staging area). Since the material has a high percentage of sands, simple dewatering within the barge or in a temporary stockpile is all the dewatering that is anticipated to be required. The dredged material would be transported by truck or rail to an approved Subtitle D Landfill. There are two landfills in the region which have rail access and accept these sediments: Roosevelt Regional Landfill (Klickitat County, Washington) and Oregon Waste Systems Columbia Ridge Landfill and Recycling Center (Arlington, Oregon).

PCB material that is regulated under TSCA (>50 mg/kg) will be handled separately from the rest of the sediment. This material will be dredged, dewatered, and containerized for transport to the Oregon Waste Systems Columbia Ridge Hazardous Waste Landfill, Arlington, Oregon.

9.2.6 Cost

The estimated cost for this alternative is $891,500. This preliminary cost estimate is detailed in **Table 9-1**.

9.2.7 Community Concerns

It is not possible to evaluate the community's concerns regarding this alternative until after the public comment period. The public comment period will extend for a 30-day period during which the public will be asked to provide their evaluation, advice, and any concerns they have regarding all potential alternatives.

9.2.8 Employment of Recycling, Reuse, and Waste Minimization

There is no use of recycling, reuse, or waste minimization practices in this alternative since all dredged sediments would be landfilled.

9.3 ALTERNATIVE 3: MECHANICAL DREDGING WITH TREATMENT AT HOLNAM

Under this alternative, contaminated sediments would be removed using a mechanical clamshell dredge located on a barge; dewatered and stockpiled either on an adjacent barge or at an upland location; and transported to an appropriate treatment facility. As discussed in **Chapter 7.0**, the only identified feasible treatment facility is Holnam, Inc. in Seattle. Holnam can use contaminated soils or sediments as raw material in their cement manufacturing process. Sediments with PCB concentrations greater than approximately 20 mg/kg DW are not accepted at Holnam and would require disposal in an appropriate landfill.

9.3.1 Overall Protection of Human Health and the Environment

This alternative will provide protection to human health and the environment by removing all contamination at levels greater than the SQS (or below SQS for PCBs) from the site. These contaminated sediments would be used as raw materials in the production of cement. Any contaminated sediments that could not be treated due to high levels of PCBs would be disposed of at an appropriate landfill. Engineering controls would be instituted during the dredging and dewatering operation to ensure all dredged material and water is properly contained and disposed of.

9.3.2 Compliance with Cleanup Standards and Applicable Laws

This alternative would comply with the cleanup standards and all applicable laws. Water quality permits would be obtained and measures would be implemented to ensure that water quality is not degraded during dredging and dewatering operations.

Table 9-1
ALTERNATIVE 2 COST ESTIMATE
MECHANICAL DREDGING WITH UPLAND DISPOSAL

Category	Quantity	Unit	Unit Cost	Cost
Preconstruction				
Mobilization/Demobilization	1	LS	$15,000.00	$15,000
Pre and Post Dredge Surveys	2	EA	$2,000.00	$4,000
Upland Dewatering/Stockpile Area <1>	1	LS	$25,000.00	$25,000
Contaminated Sediment Dredge, Haul and Dispose				
Mechanical Dredging <2>	6,900	CY	$9.10	$62,790
Offload from Barge	6,900	CY	$3.70	$25,530
Rehandle into Trucks	6,900	CY	$1.50	$10,350
Subtitle D Landfill Disposal				
Truck & Rail Transport, Tipping Fees	6,900	CY	$45.00	$310,500
Hazardous Sediment Dredge, Haul and Dispose				
Mech. Dredging (Closed Bucket)	300	CY	$17.60	$5,280
Offload and Rehandling	300	CY	$9.30	$2,790
Water Collection/Treatment <3>	1	LS	$15,000.00	$15,000
Disposal at Landfill	300	CY	$300.00	$90,000
Dredge Site Monitoring				
Bathymetric Surveys	1	EA	$2,000.00	$2,000
Water Quality Sampling	1	LS	$3,600.00	$3,600.00
Post-Dredge Sediment Sampling	1	LS	$17,600.00	$17,600.00
Cost Subtotal				$589,440
Bonding, Taxes	1	EA	10%	$58,944
Profit	1	EA	10%	$64,838
Contingency	1	EA	25%	$178,306
TOTAL ESTIMATED COST				$891,528

1. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the upland dewatering/stockpile facility is dependent on
2. Assumes water will be able to be discharged directly into Duwamish River with only filtration and no treatment.
3. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the water collection system and treatment of water dep

LS = Lump Sum
EA = Each
CY= Cubic Yards, based on in-situ volume

9.3.3 Short-Term Effectiveness

The dredge and upland rehandling sites would present a low risk to the public because there would be no access to these areas. Since the sediments would be transported by trucks or rail cars to the landfill, there is a potential for public exposure to the sediment by leakage or accidents during transport. There is high risk for possible direct sediment contact by workers, especially during rehandling from the barge to trucks or rail cars, and during rehandling from a temporary stockpile/dewatering site to trucks or rail cars. Health and safety procedures would be required to protect workers during these operations.

Dredging of the sediments could create limited adverse water quality impacts at the dredging site. Raising and lowering the clamshell bucket can cause sediment suspension and suspended contaminants can be moved by river currents, thus spreading contamination. If this resuspension and turbidity occurs at levels of concern, it could be controlled by using special clamshell buckets designed specifically to reduce releases of contaminated sediments, and/or by the use of silt curtains or air curtains to limit the migration of suspended sediments. Because there is a high percentage of sand at the Norfolk site, the majority of suspended sediments would settle rapidly at the project site and these additional silt control measures may not be required.

9.3.4 Long-Term Effectiveness

This alternative would be effective in the long-term because all designated contaminated sediments would be removed from the site. Sediments with PCB concentrations greater than 50 mg/kg DW would be transported to the hazardous waste landfill in Arlington, Oregon for proper disposal. Sediments with PCB concentration between 20 mg/kg and 50 mg/kg would be transported and disposed of at a Subtitle D landfill. All other sediments would be transported to Holnam, Inc., Seattle; thermally treated in a cement kiln; and residuals incorporated into a cement matrix where they will be permanently isolated from the environment.

9.3.5 Implementability

This alternative is readily implementable. Mechanical dredging equipment is available locally and is a reliable and proven technology. Permits need to be obtained; however, this is a relatively straightforward process and the technology is accepted. Constraints at the Norfolk site pose some potential logistical problems for a contractor. These constraints include an existing concrete bridge immediately downstream of the Norfolk site, steep banks on both sides of the Duwamish River, medium to dense vegetative cover at the top of both banks, and an existing covered walkway on the east bank of the site.

Clearance under the concrete bridge may pose problems during mobilization of equipment to the site, and during transport of the barge to and from an upland rehandling site. Bridge clearance is approximately 20 feet at MLLW. A typical barge that may be used for this project draws approximately three to four feet when empty with a freeboard of approximately eight to twelve feet. There should be sufficient bridge clearance for barge movement, but would be dependent on vessel draft and the stage of the tide. The rest of the dredging equipment, including crane and clamshell, would have difficulty in clearing the bridge at higher tides but may clear the bridge at low tides. Another option is to mobilize the crane upland and assemble the plant upstream of the bridge. An upland staging area would be required to load the dredging equipment onto the barge.

Dredged sediment would be temporarily deposited into a second barge which would be offloaded at an upland rehandling site (i.e., possibly the same site as the staging area). The dredged material would be transported by truck to Holnam for treatment. Alternatively, the barge could be hauled directly to the Holnam dock and the sediment handled directly from the barge. However, Holnam has expressed a preference that material be transported to the site by truck rather than across its dock. Additionally, the storage area for sediments is limited at Holnam. Depending on dredging rates and total volumes, Holnam may not be able to fully accommodate all of the dredged sediments. Holnam's ability to process the sediments will be determined during the design phase of this project.

PCB material that is regulated under TSCA (>50 mg/kg) will be handled separately from the rest of the sediment. This material will be dredged, dewatered, and containerized for transport to the Oregon Waste Systems Columbia Ridge Hazardous Waste Landfill, Arlington, Oregon.

9.3.6 Cost

The estimated cost for this alternative is $891,500. This preliminary cost estimate is detailed in **Table 9-2**. PCB material between 20 to 50 mg/kg will need to be transported and disposed at a Subtitle D landfill. Because the volume of this material is unknown and the projected disposal cost is about equal to Holnam disposal, there is no separate cost figure included in the budget.

9.3.7 Community Concerns

It is not possible to evaluate the community's concerns regarding this alternative until after the public comment period. The public comment period will extend for a 30-day period during which the public will be asked to provide their evaluation, advice, and any concerns they have regarding all potential alternatives.

9.3.8 Employment of Recycling, Reuse, and Waste Minimization

This alternative would treat all organic contaminants by thermal means and would recycle and immobilize all residuals by incorporating them in cement. Some sediments may have unacceptably high concentrations of PCB which could not be treated at Holnam. These sediments would be disposed of in an appropriate landfill.

Table 9-2
ALTERNATIVE 3 COST ESTIMATE
MECHANICAL DREDGING WITH TREATMENT AT HOLNAM

Category	Quantity	Unit	Unit Cost	Cost
Preconstruction				
Mobilization/Demobilization	1	LS	$15,000.00	$15,000
Pre and Post Dredge Surveys	2	EA	$2,000.00	$4,000
Upland Dewatering/Stockpile Area <1>	1	LS	$25,000.00	$25,000
Contaminated Sediment Dredge, Haul and Dispose				
Mechanical Dredging <2>	6,900	CY	$9.10	$62,790
Offload from Barge	6,900	CY	$3.70	$25,530
Rehandle into Trucks	6,900	CY	$1.50	$10,350
Holnam Inc. Thermal Treatment				
Includes truck transport <3>	6,900	CY	$45.00	$310,500
Hazardous Sediment Dredge, Haul and Dispose				
Mech. Dredging (Closed Bucket)	300	CY	$17.60	$5,280
Offload and Rehandling	300	CY	$9.30	$2,790
Water Collection/Treatment <3>	1	LS	$15,000.00	$15,000
Disposal at Landfill	300	CY	$300.00	$90,000
Dredge Site Monitoring				
Bathymetric Surveys	1	EA	$2,000.00	$2,000
Water Quality Sampling	1	LS	$3,600.00	$3,600.00
Post-Dredge Sediment Sampling	1	LS	$17,600.00	$17,600.00
Cost Subtotal				$589,440
Bonding, Taxes			10%	$58,944
Profit			10%	$64,838
Contingency			25%	$178,306
TOTAL ESTIMATED COST				$891,528

1. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the upland dewatering/stockpile facility is dependent on size, type of barrier, etc.

2. Assumes water will be able to be discharged directly into Duwamish River with only filtration and no treatment.

3. For purposes of estimating cost, it is assumed that the material to be treated at Holnam will be trucked into the facility.

4. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the water collection system and treatment of water depends on contractor operations and agency requirements.

LS = Lump Sum
EA = Each
CY= Cubic Yards, based on in-situ volume

9.4 ALTERNATIVE 4: HYDRAULIC DREDGING WITH UPLAND DISPOSAL

Under this alternative, contaminated sediments would be removed using a hydraulic dredge; dewatered in an adjacent barge; transferred from the barge to lined, leak-tight trucks or rail cars; and transported to an appropriate landfill. Some of the sediments may require disposal in a hazardous waste landfill, while most sediments could be disposed of in a Subtitle D municipal landfill.

9.4.1 Overall Protection of Human Health and the Environment

This alternative will provide protection of human health and the environment by removing all contamination at levels greater than the SQS (or below SQS for PCBs) from the site. These contaminated sediments would be relocated to an appropriate landfill, where they would be isolated from human contact and would be contained from the environment. Engineering controls would be instituted during dredging and dewatering operations to ensure dredged material and water are properly contained and disposed of.

9.4.2 Compliance with Cleanup Standards and Applicable Laws

This alternative would comply with cleanup standards and all applicable laws. Water quality permits would be obtained and measures would be implemented to ensure that water quality is not degraded during dredging and dewatering operations. The dredged sediments would be placed in an appropriate, fully permitted landfill. All required permits would be obtained prior to performing the remedial activities.

9.4.3 Short-Term Effectiveness

The dredge and barge storage areas would present a low risk to the public because there would be no access to these areas. During the hydraulic dredging and barge disposal operation, the sediments would be contained inside discharge pipes or within the barge. Discharge of water from the barge would be monitored during construction. Due to the generally low concentrations of contaminants in the sediments, it is expected that the water quality will be sufficient that it can be discharged directly to the river. If water quality requirements established during remedial design were not met at the discharge location, operations would be modified as provided for in remedial design so that discharges would meet the requirements.

Since the sediments would be transported by trucks from the rehandling area to the transfer station, there is limited potential for public exposure to the sediment by leakage or traffic accidents during transport. There is high risk for possible direct sediment contact by workers, especially during rehandling from the barge to trucks and during rehandling from a temporary stockpile/dewatering site to trucks. Health and safety procedures would be required to protect workers.

Hydraulic dredging of the sediments would create limited adverse water quality impacts at the dredging site. The entrainment of water and sediment to create the slurry can cause sediment suspension and suspended contaminants can be moved by river currents, thus spreading contamination. Hydraulic dredging typically causes less suspension of sediments than mechanical dredging. Because there is a high percentage of sand at the Norfolk site, the majority of suspended sediments would settle rapidly at the project site.

9.4.4 Long-Term Effectiveness

This alternative would be effective in the long-term because all designated contaminated sediments would be removed from the site. The sediments would be placed in a municipal landfill which conforms with Subtitle D of RCRA. This will contain and isolate contaminants from leaching out of the sediments to the environment.

9.4.5 Implementability

This alternative is implementable. Hydraulic dredging equipment is available locally and is a reliable, proven technology. Permits need to be obtained; however, this is a relatively straightforward process and the technology is accepted. Constraints at the Norfolk site pose some potential logistical problems for a contractor. These constraints include an existing concrete bridge immediately downstream of the Norfolk site, steep banks on both sides of the Duwamish River, and private property which is generally unavailable for use in staging operations.

Clearance under the concrete bridge may pose problems during mobilization of equipment to the site, namely the hydraulic dredge and barges. Bridge clearance is approximately 20 feet at MLLW. A typical barge that may be used for this project draws approximately three to four feet when empty with a freeboard of approximately eight to twelve feet. There should be sufficient bridge clearance for barge movement. A smaller hydraulic dredge would not have difficulty in clearing the bridge at lower tides. An upland staging and dewatering area adjacent to the dredge area for equipment mobilization would probably not be required for this alternative.

The logistics involved with hydraulic dredging are significant. Hydraulic dredging incorporates a large volume of water compared to the volume of sediment removed. Typically, discharge from hydraulic dredging is into large diked areas on adjacent uplands that is designed for suspended sediment settling and dewatering. Adjacent upland areas are not available for this project. Therefore, this analysis evaluates the possibility of using barges to achieve settling and dewatering. However, using barges for suspended sediment settling and dewatering is not typically done.

As envisioned, the sediment slurry would be pumped into a barge. No overflow of the barge would be allowed. Once filled to capacity, the slurry would be allowed to settle. Because the majority of the sediment is sand, the time required for suspended sediment settling would be relatively short, probably within several hours. The hydraulic dredge could sit idle while sediment was dewatering within the barge. The in situ sediment average production rate for the hydraulic dredge will probably be significantly less than the mechanical dredge due to using barges as dewatering facilities. If the maximum production rate was desired, multiple dewatering barges would be required. Using either approach, idle dredge or multiple barges, would significantly increase the cost of the operation. Discharge of supernatant water from the barge could be accomplished by allowing the water to pass through hay bales or pumping the water through a filter system which would remove suspended sediments from the water. Due to the generally low concentrations of contaminants in the sediments, this is expected to be sufficient treatment. The dewatered dredged material would be transported by truck or rail to an approved Subtitle D Landfill. There are two landfills in the region which have rail access and accept these sediments: Roosevelt Regional Landfill (Klickitat County, Washington) and Oregon Waste Systems Columbia Ridge Landfill and Recycling Center (Arlington, Oregon).

PCB material that is regulated under TSCA (>50 mg/kg) will be handled separately from the rest of the sediment. This material would need to be removed using mechanical dredging equipment. Hydraulic dredging would require the use of a separate barge for storage and dewatering plus collection, testing, and treatment of large amounts of water. TSCA-regulated material will be dredged, dewatered, and containerized for transport to the Oregon Waste Systems Columbia Ridge Hazardous Waste Landfill, Arlington, Oregon.

The logistical difficulties of dewatering associated with hydraulic dredging would increase the time to complete the project and increase the total cost of construction, making this alternative undesirable.

9.4.6 Cost

The estimated cost for this alternative is $1,028,500. This preliminary cost estimate is detailed in **Table 9-3.**

9.4.7 Community Concerns

It is not possible to evaluate the community's concerns regarding this alternative until after the public comment period. The public comment period will extend for a 30-day period during which the public will be asked to provide their evaluation, advice, and any concerns they have regarding all potential alternatives.

9.4.8 Employment of Recycling, Reuse, and Waste Minimization

There is no use of recycling, reuse, or waste minimization practices in this alternative, since all dredged sediments would be landfilled.

Table 9-3
ALTERNATIVE 4 COST ESTIMATE
HYDRAULIC DREDGING WITH UPLAND DISPOSAL

Category	Quantity	Unit	Unit Cost	Cost
Preconstruction				
Mobilization/Demobilization	1	LS	$30,000.00	$30,000
Pre and Post Dredge Surveys	2	EA	$2,000.00	$4,000
Upland Dewatering/Stockpile Area <1>	1	LS	$25,000.00	$25,000
Contaminated Sediment Dredge, Dewater, Haul and Dispose				
Hydraulic Dredging & Dewatering	6,900	CY	$18.00	$124,200
Offload from Barge	6,900	CY	$4.70	$32,430
Rehandle into Trucks	6,900	CY	$1.50	$10,350
Subtitle D Landfill Disposal				
Truck & Rail Transport, Tipping Fees	6,900	CY	$45.00	$310,500
Hazardous Sediment Dredge, Dewater, Haul and Dispose				
Mech. Dredging (Closed Bucket)	300	CY	$17.60	$5,280
Offload and Rehandle	300	CY	$9.30	$2,790
Water Collection/Treatment <2>	1	LS	$15,000.00	$15,000
Disposal at Landfill	300	CY	$300.00	$90,000
Dredge Site Monitoring				
Bathymetric Surveys	1	EA	$2,000.00	$2,000
Water Quality Sampling	1	LS	$10,800.00	$10,800.00
Post-Dredge Sediment Sampling	1	LS	$17,600.00	$17,600.00
Cost Subtotal				$679,950
Bonding, Taxes	1	EA	10%	$67,995
Profit	1	EA	10%	$74,795
Contingency	1	EA	25%	$205,685
TOTAL ESTIMATED COST				$1,028,424

1. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the upland dewatering/stockpile facility is type of barrier, etc.
2. Assumes water will be able to be discharged directly into Duwamish River with only filtration and no treatment.
3. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the water collection system and treatmen water depends on contractor operations and agency requirements.

LS = Lump Sum
EA = Each
CY= Cubic Yards, based on in-situ volume

9.5 ALTERNATIVE 5: HYDRAULIC DREDGING WITH TREATMENT AT HOLNAM

Under this alternative, contaminated sediments would be removed using a hydraulic dredge, dewatered, and transported to an appropriate treatment facility. As discussed in **Chapter 7.0**, the only feasible treatment facility is Holnam, Inc. in Seattle. Holnam can use contaminated soils or sediments as raw material in their cement manufacturing process. Sediments with PCB concentrations greater than approximately 20 mg/kg are not accepted at Holnam and would require disposal in an appropriate landfill.

9.5.1 Overall Protection of Human Health and the Environment

This alternative will provide protection to human health and the environment by removing all contamination at levels greater than the SQS (or below SQS for PCBs) from the site. These contaminated sediments would be used in the production of cement and therefore the contaminants would be destroyed and/or immobilized. Any contaminated sediments that could not be treated due to high levels of PCBs would be transported to an appropriate landfill. Engineering controls would be instituted during dredging and dewatering operations to ensure dredged material and water is properly contained and disposed of.

9.5.2 Compliance with Cleanup Standards and Applicable Laws

This alternative would comply with the cleanup standards and all applicable laws. Water quality permits would be obtained and measures would be implemented to ensure that water quality is not degraded during dredging operations.

9.5.3 Short-Term Effectiveness

The dredge and barge storage areas would present a low risk to the public because there would be no access to these areas. During the hydraulic dredging and barge disposal operation, the sediments would be contained inside discharge pipes or within the barge. Discharge of water from the barge would be monitored during construction. Due to the generally low concentrations of contaminants in the sediments, it is expected that the water quality will be sufficient that it can be discharged directly to the river. If water quality requirements established during remedial design were not met at the discharge location, operations would be modified so that discharges would meet the requirements.

Since the sediments would probably be transported by trucks from the barge to Holnam, there is limited potential for public exposure to the sediment by leakage or traffic accidents during transport. There is high risk for possible direct sediment contact by workers, especially during rehandling from the barge to trucks. Health and safety procedures would be required to protect workers.

Hydraulic dredging of the sediments would create limited adverse water quality impacts at the dredging site. The entrainment of water and sediment to create the slurry can cause sediment suspension and suspended contaminants can be moved by river currents, thus spreading contamination. Hydraulic dredging typically causes less suspension of sediments than mechanical dredging. Because there is a high percentage of sand at the Norfolk site, the majority of suspended sediments would settle rapidly back in the project site.

9.5.4 Long-Term Effectiveness

This alternative would be effective in the long-term because all known contaminated sediments would be removed from the site. Sediments with PCB concentrations greater than 50 mg/kg DW would be transported to the hazardous waste landfill in Arlington, Oregon for proper disposal. Sediments with PCB concentrations between 20 mg/kg and 50 mg/kg would be transported to a RCRA Subtitle D landfill. All other sediments would be transported to Holnam, Inc., Seattle; thermally treated in a cement kiln; and residuals incorporated into a cement matrix where they will be permanently isolated from the environment.

9.5.5 Implementability

This alternative is implementable. Hydraulic dredging equipment is available locally and is a reliable and proven technology. Permits need to be obtained; however, this is a relatively straightforward process and the technology is accepted. Constraints at the Norfolk site pose some potential logistical problems for a contractor. These constraints include an existing concrete bridge immediately downstream of the Norfolk site; steep banks on both sides of the Duwamish River; and private property that is generally unavailable for use in staging operations.

Clearance under the concrete bridge may pose problems during mobilization of equipment to the site. Bridge clearance is approximately 20 feet at MLLW. A typical barge that may be used for this project draws approximately three to four feet when empty with a freeboard of approximately eight to twelve feet. There should be sufficient bridge clearance for barge movement. A smaller hydraulic dredge would not have difficulty in clearing the bridge at lower tides. An upland staging area adjacent to the dredge area for equipment mobilization would probably not be required for this alternative.

The logistics involved with hydraulic dredging are significant. Hydraulic dredging incorporates a large volume of water compared to the volume of sediment removed. In order to offload the sediment from the barge, the water would first need to be discharged. Because the majority of the sediment is sand, the time required for suspended sediment settling would be relatively short, probably within several hours.

The hydraulic dredge could sit idle while sediment was dewatering within the barge. The in-situ sediment average production rate for the hydraulic dredge will probably be significantly less than the mechanical dredge due to using barges as dewatering facilities. If the maximum production rate was desired, multiple dewatering barges would be required. Using either approach, idle dredge or multiple barges, would significantly increase the cost of the operation. Discharge of supernatant water from the barge would be accomplished by allowing the water to pass through hay bales, or pumping the water through a filter system which would remove suspended sediments from the water. Due to the generally low concentrations of contaminants in the sediments, this is expected to be sufficient treatment. The material would be allowed to dewater within the barge before it was offloaded via crane into lined trucks. Since the material has a high percentage of sands, simple dewatering within the barge is the only dewatering that is anticipated to be required. The dredged material would be transported by truck to Holnam for treatment. Alternatively, the barge could be hauled directly to the Holnam dock and the sediment handled directly from the barge. However, Holnam prefers that material be transported to the site by truck. It is possible that the volumes of sediment would be greater than Holnam may require. It will not be possible to estimate their requirements until the design phase.

PCB material that is regulated under TSCA (>50 mg/kg) will be handled separately from the rest of the sediment. This material would be discharged into a separate barge for storage and dewatering. The supernatant water may need to be treated as wastewater discharge before being returned to the Duwamish Waterway. TSCA-regulated material will be dredged, dewatered, and containerized for transport to the Oregon Waste Systems Columbia Ridge Hazardous Waste Landfill, Arlington, Oregon.

The logistical difficulties of dewatering associated with hydraulic dredging would increase the time to complete the project and increase the total cost of construction, making this alternative undesirable.

9.5.6 Cost

The estimated cost for this alternative is $1,028,500. This preliminary cost estimate is detailed in **Table 9-4**. PCB material between 20 to 50 mg/kg will need to be transported and disposed at a Subtitle D landfill. Because the volume of this material is unknown and the projected disposal cost is about equal to Holnam disposal, there is no separate cost figure included in the budget.

9.5.7 Community Concerns

It is not possible to evaluate the community's concerns regarding this alternative until after the public comment period. The public comment period will extend for a 30-day period during which the public will be asked to provide their evaluation, advice, and any concerns they have regarding all potential alternatives.

9.5.8 Employment of Recycling, Reuse, and Waste Minimization

This alternative treats all organic contaminants by thermal means and would recycle all residuals by incorporating them in cement.

Table 9-4
ALTERNATIVE 5 COST ESTIMATE
HYDRAULIC DREDGING WITH TREATMENT AT HOLNAM

Category	Quantity	Unit	Unit Cost	Cost
Preconstruction				
Mobilization/Demobilization	1	LS	$30,000.00	$30,000
Pre and Post Dredge Surveys	2	EA	$2,000.00	$4,000
Upland Dewatering/Stockpile Area <1>	1	LS	$25,000.00	$25,000
Contaminated Sediment Dredge, Dewater, Haul and Dispose				
Hydraulic Dredging & Dewatering	6,900	CY	$18.00	$124,200
Offload from Barge	6,900	CY	$4.70	$32,430
Rehandle into Trucks	6,900	CY	$1.50	$10,350
Holnam Inc. Thermal Treatment				
Includes Truck Transport <2>	6,900	CY	$45.00	$310,500
Hazardous Sediment Dredge, Dewater, Haul and Dispose				
Mech. Dredging (Closed Bucket)	300	CY	$17.60	$5,280
Offload and Rehandle	300	CY	$9.30	$2,790
Water Collection/Treatment <3>	1	LS	$15,000.00	$15,000
Disposal at Landfill	300	CY	$300.00	$90,000
Dredge Site Monitoring				
Bathymetric Surveys	1	EA	$2,000.00	$2,000
Water Quality Sampling	1	LS	$10,800.00	$10,800.00
Post-Dredge Sediment Sampling	1	LS	$17,600.00	$17,600.00
Cost Subtotal				$679,950
Bonding, Taxes	1	EA	10%	$67,995
Profit	1	EA	10%	$74,795
Contingency	1	EA	25%	$205,685
TOTAL ESTIMATED COST				$1,028,424

1. The lump sum estimated cost is for comparison purposes only. Actual cost to construct upland dewatering/stockpile facility is dependent on size
2. For purposes of estimating cost, it is assumed that the material to be treated at Holnam will be transported to Holnam by truck.
3. The lump sum estimated cost is for comparison purposes only. Actual cost to construct the water collection system and treatment of water depends on contractor operations and agency requirements.

LS = Lump Sum
EA = Each
CY= Cubic Yards, based on in-situ volume

9.6 COMPARISON OF REMEDIAL ALTERNATIVES

A comparative analysis is conducted to evaluate the relative performance of each alternative in relation to each of the evaluation criteria. The purpose of this comparison is to identify advantages and disadvantages of each alternative relative to the others. This will facilitate the selection process by identifying key tradeoffs. For each criterion, the alternatives are qualitatively ranked in order of desirability. **Table 9-5** presents a summary of the alternatives comparison.

9.6.1 Overall Protection of Human Health and the Environment

Alternative 1 would not provide any additional protection of human health and the environment. Alternatives 2, 3, 4, and 5 protect human health and the environment by removing all contaminated sediments from the site. Under Alternatives 2 and 4, the sediments would be landfilled in a Subtitle D landfill, which are designed to isolate their contents from the environment. Alternatives 3 and 5 would thermally treat the sediments which would destroy the organic contaminants and the residuals would be incorporated into cement.

Overall Protection Ranking: Alternative 2, Alternative 3, Alternative 4, Alternative 5 > Alternative 1.

9.6.2 Compliance with Cleanup Standards and Applicable Laws

Alternative 1 would not comply with cleanup standards or applicable laws. Alternatives 2, 3, 4, and 5 would dredge all sediments from the site with contaminant concentrations greater than the SQS (or below SQS for PCBs). Under each of these four alternatives, all applicable permits would be obtained and complied with.

Compliance Ranking: Alternative 2, Alternative 3, Alternative 4, Alternative 5 > Alternative 1.

9.6.3 Short-Term Effectiveness

This criterion is not applicable to Alternative 1. Alternatives 2 and 3 employ mechanical dredging techniques which could create limited adverse water quality impacts at the dredging site. If resuspension of contaminated sediments and turbidity occurs at levels of concern, it could be controlled by using special clamshell buckets designed specifically to reduce releases of contaminated sediments, or by the use of silt or air curtains to limit the migration of suspended sediments. However, since there is a high percentage of sand at the Norfolk site, the majority of suspended sediments would settle rapidly and the special clamshell and silt curtains may not be required during mechanical dredging. Alternatives 4 and 5 employ hydraulic dredging techniques. Generally, hydraulic dredging causes less resuspension than mechanical dredging techniques. Water quality monitoring during dredging operations would be required by the permits to ensure water quality standards were met. Water quality would also be monitored during dewatering operations to ensure compliance with permits and standards.

Table 9-5
ALTERNATIVES COMPARISON

Criterion	Alternative 1: No Action	Alternative 2: Mechanical Dredge with Upland Disposal	Alternative 3: Mechanical Dredge with Treatment	Alternative 4: Hydraulic Dredge with Upland Disposal	Alternative 5: Hydraulic Dredge with Treatment
Overall protection of human health and the environment.	Potential for human exposure to contaminated sediments. Uptake of contaminants by organisms and subsequent ingestion is primarily human exposure pathway	Removal of all contaminated sediments would eliminated exposure pathways from site.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Compliance with cleanup standards and applicable laws.	Does not comply.	Removal of all contaminated sediments will comply with cleanup standards. All required permits would be obtained and complied with.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Short-term effectiveness.	Not applicable.	Low risk to the public at the dredge and handling sites. Workers required to use proper health and safety procedures. Potential risk to environment due to water quality issues; these can be addressed.	Same as Alternative 2.	Low risk to the public and environment at dredge and handling sites. Workers required to use proper health and safety procedures.	Same as Alternative 4.
Long-term effectiveness.	None.	Effective at the site since all contaminated sediments are removed. Dredged sediments would be disposed of at a Subtitle D landfill, which is designed for long-term effectiveness.	Effective at the site since all contaminated sediments are removed. Dredged sediments would be treated in a cement kiln and residuals would be incorporated into cement matrix.	Same as Alternative 2.	Same as Alternative 3.

Table 9-5 (continued)
ALTERNATIVES COMPARISON

Criterion	Alternative 1: No Action	Alternative 2: Mechanical Dredge with Upland Disposal	Alternative 3: Mechanical Dredge with Treatment	Alternative 4: Hydraulic Dredge with Upland Disposal	Alternative 5: Hydraulic Dredge with Treatment
Implementability.	No action to implement.	Easily implemented. Somewhat smaller equipment than would normally be used may be required to allow access under the downstream concrete bridge.	Same as Alternative 2.	Dredging activity is easily implemented. Large volumes of water will make it difficult to economically dewater dredged material.	Same as Alternative 4.
Cost.	No cost.	$891,500	$891,500	$1,028,500	$1,028,500
Community concerns.	Assumed to be unacceptable.	Not possible to evaluate until after public comment period.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Employment of recycling, reuse, and waste minimization.	None.	None.	Sediments treated, then incorporated into cement matrix.	None.	Sediments treated, then incorporated into cement matrix.

Under Alternatives 2, 3, 4, and 5, the dredge and upland rehandling sites would present a low risk to the public because there would be limited access to these areas. Since the sediments would be transported by trucks or rail cars to the landfill (Alternatives 2 and 3) or trucks to the treatment plant (Alternatives 4 and 5), there is a limited potential for public exposure to the sediment by leakage or accidents during transport. There is high risk for possible direct sediment contact by workers, especially during rehandling from the barge to trucks or rail cars and during rehandling from a temporary stockpile/dewatering site to trucks or rail cars. Health and safety monitoring would be required to protect workers during these operations. Alternatives 2, 3, 4, and 5 would be equally effective during construction and implementation. Alternatives 2 and 3 may require additional procedures to ensure water quality is maintained; however, this is easily implemented. Alternatives 2, 3, 4, and 5 are effective immediately following construction as the construction effort completes remedial goals.

Short-Term Effectiveness Ranking: Alternative 4, Alternative 5 > Alternative 2, Alternative 3 > Alternative 1.

9.6.4 Long-Term Effectiveness

Alternative 1 would not provide long-term effectiveness. Alternatives 2, 3, 4, and 5 would provide long-term effectiveness at the site by removing all designated contaminated sediments from the site.

Under Alternatives 2 and 4, the sediments would be disposed of in a Subtitle D landfill. These landfills are designed to isolate contaminants from the environment. Long-term monitoring is performed by the landfill operators to ensure and verify that all material remains contained.

Under Alternatives 3 and 5, the sediments would be transported to Holnam for treatment. The sediments would be used as raw materials in their cement manufacturing process. Organic contaminants are thermally treated, and all residuals are then incorporated into the cement matrix which would isolate them from the environment and allow the material to be recycled and reused.

Long-Term Effectiveness Ranking: Alternative 3, Alternative 5 > Alternative 2, Alternative 4 > Alternative 1.

9.6.5 Implementability

Alternative 1 is a no action alternative and is easily implemented.

Alternatives 2 and 3 are easily implementable. Mechanical dredging equipment and accessory equipment is available locally and is a reliable and proven technology. Permits need to be obtained; however, this is a relatively straightforward process and the technology is accepted. Constraints at the Norfolk site pose some potential logistical problems for a contractor, but can be overcome. It is expected that approximately 7,200 cubic yards of in situ sediment (or 7,600 cubic yards of bulked sediment) will be removed.

Alternatives 4 and 5 are less easily implemented. Assuming that during hydraulic dredging operations the slurry will be approximately 15% solids by weight, a total volume of approximately 50,000 cubic yards of sediment and water would have to be handled. This is approximately 6 times more material. Due to the large volumes of water generated during the hydraulic dredging operations and the difficulty of siting a dewatering station near the site, either production rates would be significantly less than those experienced by mechanical dredging (due to dredge sitting idle during dewatering operations) or multiple barges would be required to keep up with the production rates.

There is also concern that under Alternatives 3 and 5, Holnam may not be able to handle the volumes of dredged sediment. It will not be possible to estimate their capacity until the design phase.

Implementability Ranking: Alternative 1 > Alternative 2, Alternative 3 > Alternative 4, Alternative 5.

9.6.6 Cost

The estimated total costs for each alternative are summarized below:

Alternative 1:	$0
Alternative 2:	$891,500
Alternative 3:	$891,500
Alternative 4:	$1,028,500
Alternative 5:	$1,028,500

Several line item costs for these alternatives are assumed for cost comparison and cannot be more accurately estimated until the design phase. These line items are typically denoted by using a lump sum value for the item.

Alternative 1 assumes no action with no associated costs.

Alternatives 2 and 3 have similar costs. Both alternatives use mechanical dredging for all sediments, and the upland disposal and treatment costs are also similar. Because both upland disposal (RCRA Subtitle D Landfills) and treatment costs (Holnam, Inc.) are negotiated, the average quoted prices from both facilities was used.

Alternatives 4 and 5 have similar costs and are more costly than the mechanical dredging alternatives. Alternatives 4 and 5 use hydraulic dredging for contaminated sediment, and mechanical dredging for sediment designated as hazardous. Upland disposal and treatment costs are the same as used for Alternatives 2 and 3.

Cost Desirability Ranking: Alternative 1 > Alternative 2, Alternative 3 > Alternative 4, Alternative 5.

9.6.7 Community Concerns

It is not possible to compare this criterion for the various alternatives until after the public comment period. It is assumed at this point that action alternatives are preferred over the no action alternative.

Preliminary Community Acceptance Ranking: Alternative 2, Alternative 3, Alternative 4, Alternative 5 > Alternative 1.

9.6.8 Employment of Recycling, Reuse, and Waste Minimization

Alternatives 1, 2, and 4 will not use recycling, reuse, or waste minimization practices. Alternatives 3 and 5 would treat all organic contaminants by thermal means and would recycle and reuse all residuals by incorporating them in cement.

Recycle/Reuse Ranking: Alternative 3, Alternative 5 > Alternative 1, Alternative 2, Alternative 4.

9.7 PREFERRED ALTERNATIVE

Alternative 3: Mechanical Dredging with Treatment at Holnam is selected as the preferred alternative, and Alternative 2: Mechanical Dredging with Upland Disposal, is selected as a preferred backup.

9.7.1 Justification of Preferred Alternatives

The alternatives utilizing mechanical dredging (Alternative 2 and Alternative 3) are the preferred alternatives for sediment removal. Of these choices, Alternative 3 (Mechanical Dredging with Treatment at Holnam) is preferred, since the contaminated sediments would be treated and reused, rather than disposed in a landfill. However, Alternative 2 (Mechanical Dredging with Upland Disposal) is retained as a backup, since Holnam may not be able to accommodate the entire volume of dredged material at the time the remedial action is implemented. Therefore, as much of the dredged sediment as possible will be treated at Holnam Cement, with the remainder being disposed of at a Subtitle D landfill.

Primary justification for the preferred alternatives include the following:

- The total cost associated with mechanical dredging is cheaper than hydraulic dredging, by approximately $137,000. Total costs for mechanical dredging alternatives are estimated at $891,500 while total costs for hydraulic dredging alternatives are estimated at $1,028,500.

- Mechanical dredging at the Norfolk site will be easier to implement than hydraulic dredging due to the substantially smaller volumes of generated material requiring handling (i.e., approximately six times less material). Dewatering concerns related to hydraulic dredging would require a longer construction period.
- Treatment at Holnam will destroy most organic contaminants during the thermal treatment process, and residual contamination will be incorporated in cement. Thus, the risk of contaminant exposure will be eliminated, and the treatment process provides for sediment recycling and reuse as part of the cement matrix.
- The preferred alternatives will comply with cleanup standards and applicable laws.
- The preferred alternative will remove contaminated sediment from the site and treat it, therefore community and agency acceptance is expected to be greater.

A conceptual monitoring plan for construction and post-construction periods was prepared for the preferred alternative and presented in **Appendix L**. This monitoring plan will be updated and revised based on final design and permitting requirements.

10.0 BACKFILLING EXCAVATED AREA

After excavation of the contaminated area, ground elevation throughout the area will be lowered approximately 2 to 4 feet. The length of time for the area to return to existing topographic conditions is dependent on natural events, such as winter storms, which carry large sediment loads. Backfilling the excavated area with clean fill material will speed-up the return to existing conditions. This potential activity may be implemented to increase habitat value, by providing gently sloping shorelines that fish prefer, and using backfill material, such as fine grain sand, which encourage new plant life and fish feeding. Backfilling the excavated area has been requested by several agencies participating on the SRTWG, and will be carried through to the design phase.

Returning the site to existing elevations could be accomplished using the same equipment used for site excavation. Clean material can be imported from a sand and gravel facility, or possibly obtained from U.S. Army Corps of Engineers' maintenance dredging activities in the Duwamish River or other Puget Sound regions. This would require logistical coordination between projects.

A typical operation to backfill the area would include loading a barge with clean material, hauling the barge to the project site, then rehandling the material from the barge into the excavated area using a crane with clamshell. Typical cost for purchase, haul, and placement of clean sand is approximately $7 per cubic yard. With approximately 7,200 cubic yards of material excavated, the estimated cost to backfill the area is approximately $50,400 (i.e., capital cost only). If clean sand can be obtained free of charge (i.e., U.S. Army Corps of Engineers' maintenance dredging sediments), then the cost is only for hauling and placement of material, which would be approximately $4 per cubic yard; this translates to an estimated cost of approximately $28,800 (capital cost only).

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Chapter 173-204 WAC Sediment Management Standards

Chapter 173-303 WAC Dangerous Waste Regulations

Chapter 173-304 WAC Minimum Functional Standards for Solid Waste Handling

Chapter 173-340 WAC Model Toxics Control Act Cleanup Regulation

Chapter 197-11 WAC SEPA Rules

Chapter 220-110 WAC Hydraulics Code Rules

Chapter 382-30 WAC State Aquatic Lands Management Act

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33 CFR 320 General Regulatory Policies

33 CFR 323 Permits for Structures or Work in or Affecting Navigable Waters of the United States

40 CFR 131 Federally Promulgated Water Quality Standards

40 CFR 260 Hazardous Waste Management System: General

40 CFR 300 National Oil and Hazardous Substances Pollution Contingency Plan

40 CFR 760 Toxic Substances Control Act

43 CFR 11 Natural Resource Damage Assessments